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Public perceptions of marine threats and protection from around the world

Heike K. Lotze[a,*], Haley Guest[a,b], Jennifer O'Leary[c], Arthur Tuda[d,e], Douglas Wallace[b]

[a] Department of Biology, Dalhousie University, 1355 Oxford Street, Halifax, Nova Scotia B3H 4R2, Canada
[b] Department of Oceanography, Dalhousie University, 1355 Oxford Street, Halifax, Nova Scotia B3H 4R2, Canada
[c] California Sea Grant, California Polytechnic State University, San Luis Obispo, CA, USA
[d] Kenya Wildlife Service, Coast Conservation Area, P.O. Box 82144-80100, Mombasa, Kenya
[e] Erasmus Mundus Office, Aulario Norte, Puerto Real Campus, University of Cadiz, 11519, Puerto Real, Cadiz, Spain

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ABSTRACT

The ocean is increasingly facing direct and indirect threats from multiple human activities that alter marine ecosystems worldwide. Mitigating these threats requires a global shift in the way people perceive and interact with the marine environment. Marine public perceptions research has emerged as a useful tool to understand public awareness and attitudes towards the sea. This study compares available surveys of public perceptions of marine threats and protection involving > 32,000 respondents across 21 countries. Results indicate that 70% of respondents believe the marine environment is under threat from human activities, and 45% believe the threat is high or very high. Yet when asked about the ocean's health, only 15% thought it was poor or threatened. Respondents consistently ranked pollution issues as the highest threat, followed by fishing, habitat alteration and climate change. With respect to ocean protection, 73% of respondents support marine protected areas in their region. Most respondents overestimated the area of ocean currently protected, and would like to see much larger areas protected in the future. Overall, a clear picture emerged of the perceived threats and support for protection which can inform marine managers, policy makers, conservation practitioners and educators to improve marine management and conservation programs.

1. Introduction

Human activities have strongly altered, and continue to change the state of natural ecosystems around the world (Lotze et al., 2006; Halpern et al., 2008, 2015; McCauley et al., 2015). In the marine realm, consequences of human activities can be observed as global fish stock declines, extinct or threatened species, habitat loss, pollution, invasive species, ocean warming and acidification, among others (MEA, 2005; Dulvy et al., 2009; Worm et al., 2009; McCauley et al., 2015). Mitigating these threats requires a global shift in the way humans interact with the marine environment, which can be addressed through individual or collective action as well as national and international government policies, management plans and conservation programs (Mora et al., 2009; McKinley and Fletcher, 2010). These efforts, however, require public awareness of the underlying issues and support for mitigating actions (Pomeroy and Douvere, 2008; Lotze et al., 2011; Jefferson et al., 2014; Gelcich & O'Keeffe, 2016).

To understand public awareness and attitudes towards marine environmental issues, survey studies are most often used (Fletcher et al., 2009; Potts et al., 2011; Gelcich et al., 2014; Eddy, 2014; Hawkins et al., 2016). Over the past decade, research on public perceptions of the marine environment has grown significantly and emerged as a useful tool for local and regional policy makers, managers, conservationists, scientists, and educators (Jefferson et al., 2014, 2015; Daigle et al., 2016; Gelcich et al., 2016). Public perception of and support for conservation has recently been identified as one of three emerging frontiers in perceptions research (Gelcich and O'Keeffe, 2016); particularly, understanding how the public connects with aquatic threats and engages with aquatic conservation. Given that people's perceptions determine their behavior, perceptions research is essential to inform science, policy and management towards sustainability and conservation (Gelcich and O'Keeffe, 2016; Lacroix et al., 2016; Potts et al., 2016).

Many marine perception studies have been limited to specific species groups, such as marine mammals or sharks (Scott and Parsons, 2005; Whatmough et al., 2011), specific threats, such as fisheries, pollution or ocean acidification (Kellert et al., 1995; Tudor and Williams, 2003; Frisch et al., 2015), or specific target audiences, such as fishers, managers or divers (McClanahan et al., 2012; Whatmough et al., 2011). However, an increasing number of studies has asked the

* Corresponding author. Department of Biology, Dalhousie University, 1355 Oxford Street, PO Box 15000, Halifax, Nova Scotia B3H 4R2, Canada.
E-mail address: Heike.Lotze@dal.ca (H.K. Lotze).

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public at large about their perception of the overall threat or health of the marine environment, the importance of different threats, or the level of and support for protection (Hynes et al., 2014). Most of these studies are restricted to a specific country or region, yet there are now enough data to compare existing surveys to better understand the common trends and differences in public perception of marine threats and protection around the world.

Marine protected areas (MPAs) or reserves are important tools for mitigation of harmful human activities and advancement of conservation (Roberts et al., 2005; Worm et al., 2009; Lotze et al., 2011; Edgar et al., 2014). However, as of 2016 only 4.1% of the global ocean was under some form of protection, with only 1.6% strictly or fully protected, despite scientific recommendations that 20–50% should be protected within this century (Lubchenco and Grorud-Colvert, 2015; UNEP-WCMC & IUCN, 2016). In contrast, about 15% of global land area is protected, with a goal of 17% by 2020 (CBD, 2014). Importantly, protected areas have been recognized as providing benefits for resource users, managers, tourism and the general public alike, and public awareness of MPAs can greatly enhance participatory management (Worm et al., 2006, 2009; McCook et al., 2010; Edgar et al., 2014). The establishment of MPAs, however, can be socially and politically controversial. Thus, understanding public support for MPAs is important as nations work toward achieving the 10% of marine protection recommended by the AICHI target 11 or, more ambitiously, the 30% recommended by the 2014 World Park Congress.

The goal of this paper was to quantitatively compare and synthesize available surveys of public perceptions of marine threats and protection across different regions worldwide. First, we engaged in two case studies in one industrialized (Canada) and one developing (Kenya) country. Next, we compiled comparable surveys from around the world to assess public perceptions of whether the marine environment is under threat, the level of threat to or health of the ocean, and the major types of threats. We also compared the public's support for marine protected areas across surveys, and their estimate of ocean area currently protected and desired to be protected. Our analysis aimed at identifying common patterns in public perceptions of marine threats and protection around the world that can help support global policy initiatives, management and conservation efforts, but also regional differences since solutions to marine environmental issues require understanding of the regional situation and corresponding management actions.

2. Methods

2.1. Case studies

In Nova Scotia, Canada, we performed a public perceptions survey of marine environmental issues with adults and youths, separately. The survey included 22 questions: 10 dealt with demographic information and 12 with marine environmental issues (Guest, 2013), including 5 questions about marine threats and protection (Q1, 2a, 3, 5a and 5b, Table 1) using a ranking scale or selection of answers from a list (see Appendix for details on each question and answer options). For adults, surveys were distributed by mail (n = 159), online (n = 67), and at education centers (n = 13). The mail-out survey was sent to 1560 households in coastal Nova Scotia in December 2012, and all respondents were adults (age > 18 years, 46% females, 51% males). The online survey was circulated using social media, Dalhousie University e-mail lists, and marine- and environment-related websites from July 2013 to June 2014. We also set up survey stations at three education centers in Halifax in August 2013: Discovery Center, Nova Scotia Natural History Museum, and Maritime Museum of the Atlantic. Each station contained hardcopies of surveys, pencils, a locked survey dropbox, and explanation. All results were pooled into one adult sample (n = 243).

For Nova Scotia youths (aged 11–18), the same survey was used with slight modifications of language to ensure comprehension. Surveys were distributed in-person at summer camps (n = 80) and public schools (n = 723), online (n = 18), and at education centers (n = 10). Summer camps in Halifax were visited in-person in 2013, with most youths surveyed being 12–15 years old. In November–December 2013, 11 public schools were surveyed in 5 of the province's 7 school boards, with 723 students in grades 7–12 (ages 11–18, 48% females, 44% males) participating in the survey and associated knowledge quiz. Results of the knowledge quiz have been published (Guest et al., 2015), while the survey results on marine threats and protection are presented here. The online and education center surveys were open to all ages, so all respondents age 18 or younger were included in the youth sample. All results were pooled into one youth sample (n = 826).

In Kenya, a similar survey was conducted with the general public at the Mombasa Marine Park and Reserve in June 2014. In-person surveys (n = 100, 50% females, 50% males) were performed on the beach by trained MPA staff. Generally, paper surveys were used, and read orally to participants with low literacy when necessary. Most people visiting the beach were 15–45 years of age and considered adults. The overall survey consisted of 33 questions focused on knowledge of marine and MPA systems, associated values, and perceptions of ocean health, threats, MPA benefits, coverage, and regulatory effectiveness. Results from 4 questions (Q2b, 3, 5a and 5b, Table 1) pertaining to the ocean's health, threats and protection are presented here (see Appendix for details on each question and answer options).

Table 1
Survey questions that were compared across studies. Not all studies asked all questions (see Appendix for further detail on questions and answer options in each study).

Question asked
Q1. Is the ocean under threat from human activities?
Q2a. What is the level of threat facing the oceans? or:
Q2b. What is the level of health of the marine environment?
Q3. What are the top threats to the marine environment?
Q4. Do you support marine protected areas?
Q5a. How much of the ocean do you think is currently protected? and:
Q5b. How much do you think should be protected?

2.2. Literature survey

To compare the two cases studies to other public perception surveys of marine threats and protection worldwide, we performed a literature search using the 'Web of Science' online reference system. The following search terms were selected to reflect common survey methods and the main terms used in the case study questions (Table 1) for comparability: public AND (survey* OR perception* OR opinion* OR awareness) AND (marine OR ocean) AND (i) (threat* OR human impact*), (ii) (protection OR protected area*), (iii) (management OR conservation), (iv) (environment* OR health). Overall, this search gained 573 results, of which 90 were relevant and 31 useful to our overall study topic and could be aligned with the questions asked (Table 1). However, only a subset of studies reported quantitative answers to one or more of the specific questions we were interested in (Table 1, Table A1). Thus, together with the two case studies including three surveys described above, we had 21 independent studies with 25 surveys across North and Central America, Europe, Africa, Asia, New Zealand and Australia (Table 2). Methods used in the different studies included telephone (n = 9), online (n = 6), mail-out (n = 4) and in-person surveys (n = 10) of mostly adults, but also some younger age groups, and ranging between 100 and 10,106 respondents. Together, the surveys involved a total of 32,830 respondents from 21 countries, spanning survey years from 1996 to 2016 (Table 2). In the following, each survey will be referred to with its survey ID consisting of their region, survey year and survey groups (e.g. youths, adults) if applicable (Table 2).

Table 2
List of compiled studies with their country, survey ID, method, respondents age, sample size and which questions were answered.

Reference	Country, region	Survey ID	Method	Age	Sample	Questions
Guest 2013, unpublished data	Canada, Nova Scotia	NS-adults 2013	Mail, online, in-person (education centers)	19+	243	1,2a,3,5a,5b
Guest et al., 2015, unpublished data	Canada, Nova Scotia	NS-youths 2013	In-person (schools, summer camps, education centers), online	11–18	826	1,2a,3,5a,5b
WWF-Canada 2016	Canada	CAN 2016	Online, telephone	> 18	1655	2b,4,5a
Edge Research 2002	Canada, Maritimes	MAR 2002	Telephone	> 18	300	2b,3,4,5a
	USA, New England	NE 2002	Telephone	> 18	450	2b,3,4,5a
Spruill, 1997	USA	USA 1996	Telephone	Adults	900	1
Parnell et al., 2005	USA, California	CA 2005	In-person (beaches, dive & fishing shops)	Adults	238	5a,5b
Hoelting et al., 2013	USA, Puget Sound	PS 2013	In-person (waterfront users)	Adults	1087	4
Heinen et al., 2017	Mexico	MEX 2010	In-person (at home)	Adults	300	4
Potts et al., 2011	Europe[a]	EU 2011	Online	18–64	7000	3,4
Gelcich et al., 2014	Europe[b]	EU 2014	Online	> 18	10,106	3
Fletcher et al., 2009	UK	UK 2008	In-person (at museum)	All ages	138	3
Hawkins et al., 2016	UK	UK 2005	Mail	18+	498	2b,5a,5b
		UK 2010	Mail	18+	598	2b,5a,5b
		UK 2015	Mail	18+	234	2b,5b
Hynes et al., 2014	Ireland	IRE 2012	In-person	> 18	812	2b,3,4
Ressurreição et al., 2012	Azores	AZ 2010	In-person (face to face)	> 18	692	1,2b,3,4
O'Leary and Tuda, unpublished data	Kenya	KEN 2014	In-person (on beach)	15+	100	2b,3,5a,5b
Thomassin et al., 2010	Reunion, Indian Ocean	REU 2010	Written questionnaires	Adults	469	4
Huang and You 2013	Taiwan	TAI 2010	Telephone	> 20	1068	3
Chen and Tsai 2016	Taiwan	TAI 2013	Online, in-person	18–22	825	1
Eddy 2014, WWF-NZ 2005, 2011	New Zealand	NZ 2005	Random telephone	15+	1001	1,2a,3,5a,5b
		NZ 2011	Random telephone	15+	1001	1,2a,3,5a,5b
Young and Temperton 2008	Australia	GBR 2007	Telephone	Adults	1480	4
McGregor Tan Research 2008a,b	Australia	NSW 2008	Telephone	Adults	809	4

[a] Including UK, France, Germany, Spain, Portugal, Italy, Poland.
[b] Including UK, France, Germany, Spain, Ireland, Italy, Norway, Czech Republic, Netherland, Estonia.

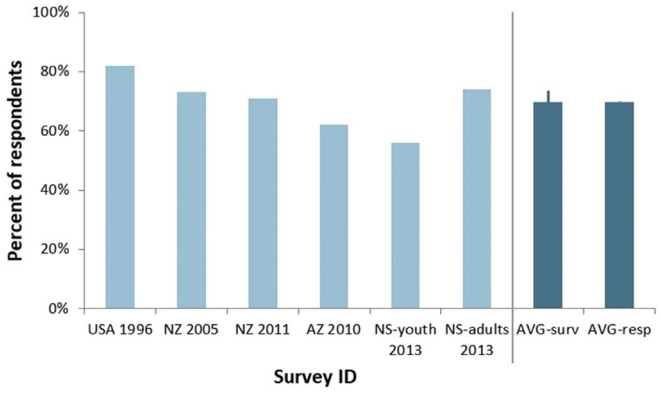

Fig. 1. Percent of respondents who believe the marine environment is under threat across individual surveys and the average across surveys (AVG-surv, mean ± SE, n = 6) and weighted by the number of respondents in each survey (AVG-resp, mean ± SE, n = 4663). See Table 2 for survey details.

2.3. Survey comparison

Quantitative results from all surveys (Table 2) were compiled in a database for comparison. Response rates (%) were either directly extracted from each survey or calculated. To summarize response rates across those surveys addressing the same question, we calculated the average across the number of surveys (AVG-surv, mean ± SE) and the average weighted by the number of respondents in each survey (AVG-resp, mean ± SE). Additional relevant surveys that asked similar but not directly comparable questions were not included in the quantitative comparison but are cited in the text.

Due to the heterogeneity of answer options among surveys, we standardized them into comparable scales or ranking systems. Seven surveys asked whether the ocean is under threat (Q1, Tables 1 and 2) with an optional yes or no answer that was directly comparable (Table A2). For Q2 (Tables 1 and 2), four surveys asked about the level of ocean threat (Q2a) and nine about the level of ocean health (Q2b), which were compared separately by grouping different answer options into comparable categories (Tables A3, A4). Thirteen surveys asked about the top threats to the marine environment (Q3, Tables 1 and 2), either using an open-answer approach or providing a list of threats to choose from (Table A5). First, all listed or mentioned threats were grouped under broad threat categories (e.g. fishing, pollution, climate change, Table A6). We then counted the number of surveys in which each broad threat category was ranked among the top three threats. We also calculated the top threats weighted by the number of respondents in each survey (Table A6). Eleven surveys asked whether respondents were in favor of or support for marine protected areas either generally or in their region (Q4, Tables 1 and 2). Answer options included yes-no or a range of choices between in favor and oppose, which were directly comparable with each other (Table A7). Finally, eleven surveys asked respondents how much of the ocean area is currently protected and nine asked how much the respondents would like to see protected (Q5a and 5b, Tables 1 and 2). Surveys either provided fixed percentages of ocean area for respondents to choose from, or allowed for open answers, which we then grouped into comparable categories (Table A8).

3. Results

3.1. Threats facing the ocean

Across six surveys (4663 respondents) asking if the ocean is under threat, 70% (± 4% SE) of respondents answered 'yes' (Fig. 1). Nova Scotian (NS) youths had the lowest response (56%), much lower than NS-adults (74%), while residents of the USA in 1996 had the highest (82%). In New Zealand, respondents in 2011 had almost an identical response rate to those in 2005. In addition, university students in Taiwan (TAI 2013) generally agreed with the statement 'Mankind is severely abusing the marine environment', with an average score of 3.9 for responses ranging from 1 (strongly disagree) to 5 (strongly agree).

The level of threat to the oceans was assessed by four surveys across 3071 respondents (Fig. 2a). Most respondents (69% ± 5%) believed the marine environment is under moderate or high threat, with 45%

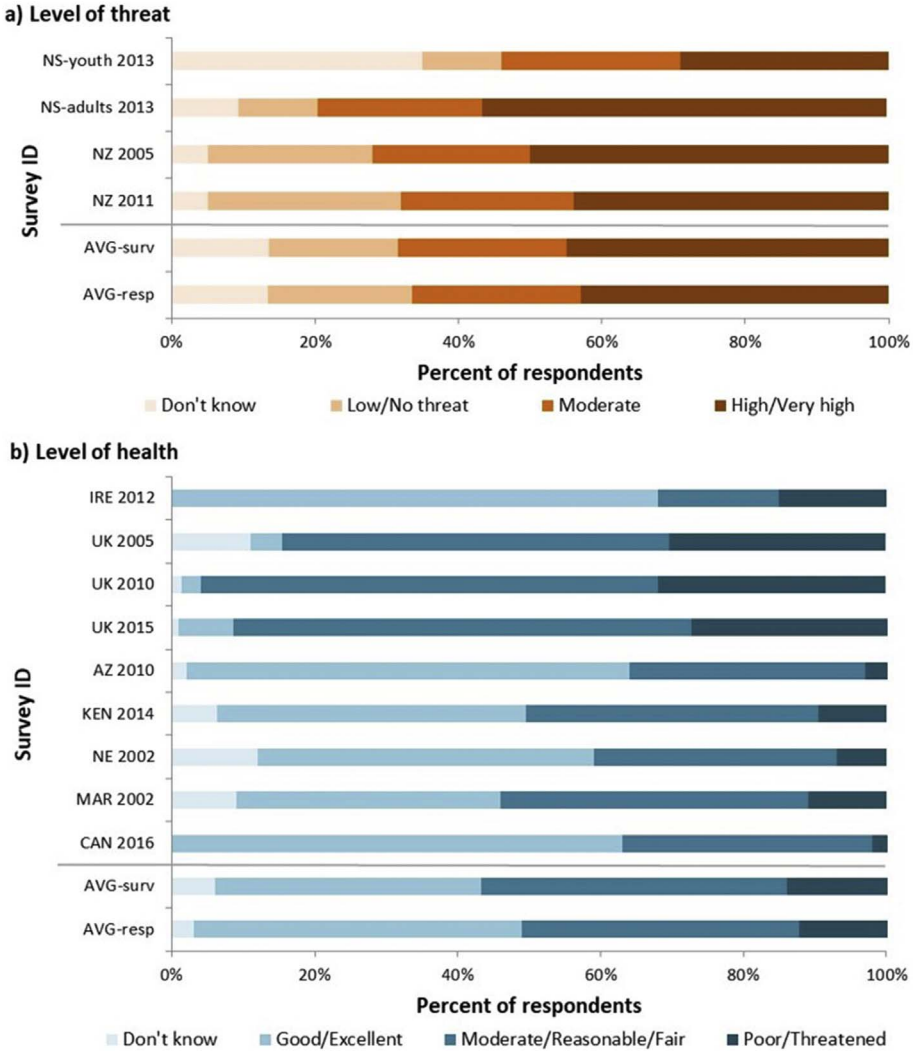

Fig. 2. Perceived (a) level of threat and (b) level of health of the ocean across individual surveys and the average across surveys (AVG-surv) and weighted by the number of respondents in each survey (AVG-resp). See Table 2 for survey details.

(± 6%) considering the threat to be high/very high. In Nova Scotia, fewer youths (29%) than adults (56%) thought the threat was high/very high, and 35% of youths answered: 'don't know'.

Nine surveys (5339 respondents) asked about the level of health of the ocean (Fig. 2b), with an average 43% (± 5%) of respondents perceiving it to be moderate/fair/reasonable, 37% (± 9%) as good/excellent, and 15% (± 4%) as poor/threatened. Highest levels of health were perceived in Ireland (IRE 2012), Canada (CAN 2016) and the Azores (AZ 2010) and lowest in the UK (UK 2005, 2010, 2015). The highest levels of 'don't know' were recorded in older surveys (NE 2002, MAR 2002 UK, 2005).

Thirteen surveys across 23,737 respondents asked to choose or list the top threats facing the oceans, either from a list of threats or as open answer (Table A5). Comparing across broad threat categories (Table A6), most respondents ranked pollution first and fisheries second, followed by habitat alteration, climate change, and biodiversity loss (Fig. 3).

Looking at the distribution of the top three threat categories across surveys and regions (Fig. 4), pollution and fishing were identified as threats in all regions, while climate change was identified in Europe, Africa, New Zealand and Canada. Habitat degradation was mentioned in Europe, Canada and Taiwan, while biodiversity loss was listed in North America and the Azores. 'Other' threats, such as invasive species, were never listed among the top three.

Within the broad threat categories, a variety of specific issues were identified by respondents in individual surveys, particularly when given

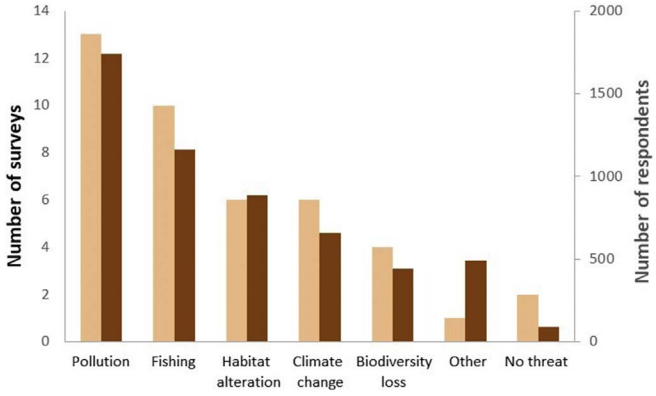

Fig. 3. Ranking of threats facing the ocean. Shown are the top three threats selected in each survey summed across all surveys (light bars, n = 13) and weighted by the number of respondents in each survey (dark bars, n = 23,737). "Other" includes ship traffic, aquaculture, invasive species, and renewable energies. See Table A6 for a full list of threats mentioned in each survey.

detailed lists or open answer options (Tables A5 and A6). Under the broad category of pollution, New Zealanders (NZ 2011) ranked pollution/sewage the highest (47%), followed by oil spills, agricultural runoff and marine debris/litter. Oil spills were frequently identified in Taiwan (50% TAI 2010) and also listed in Europe (UK 2008, EU 2014). In turn, marine debris/litter was often mentioned in Ireland (86% IRE

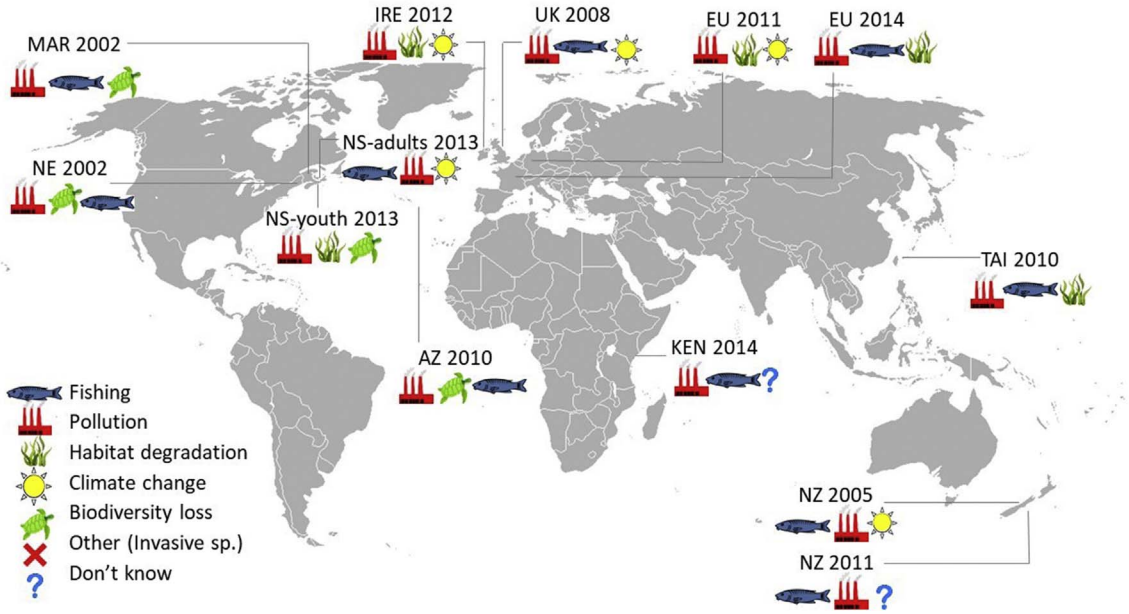

Fig. 4. Global distribution of surveys that identified the top 3 threats facing the ocean. Symbols identify broad threat categories (Table A6). See Table 2 for survey details.

2012), Europe (75% EU 2011) and Taiwan (47% TAI 2010), and respondents in Kenya (KEN 2014) were mostly concerned about plastic litter when talking about pollution. Agricultural run-off was frequently identified in North America (40% NE 2002, 43% MAR 2002) and Europe (47% IRE 2012, 24% EU 2011). Other pollution-related issues mentioned were waste dumps on the coast in the Azores and mercury pollution in Taiwan.

Among fishing issues, New Zealanders ranked commercial fishing as a greater threat than recreational fishing (67% vs. 22% NZ 2005 and 50% vs. 19% NZ 2011, respectively), while breaching quotas and poaching or illegal activities were ranked lower. Yet poaching or illegal activities were identified as important in the Azores, and bycatch and ghost fishing were mentioned in the Azores and Taiwan. In Taiwan, 11% of respondents (TAI 2010) also listed shark finning.

Climate change in general, and global warming in particular was highlighted in 10 surveys (Table A6). Ocean acidification was mentioned by youths and adults in Nova Scotia as well as respondents in Europe (EU 2011), Ireland (IRE 2012) and Taiwan (TAI 2010). Sea level rise was identified in surveys in Nova Scotia (NS-adults 2013), the UK 2008 and EU 2014. Issues regarding biodiversity loss, especially species loss and extinction were listed in 7 surveys.

A variety of habitat degradation issues were mentioned across surveys (Table A6). The extraction or drilling for oil and gas was listed in 4 North American surveys (19–43%), as well as EU 2011 (68%), IRE 2012 (81%) and NZ 2011 (7%). Coastal development was mentioned as a threat in New England (30% NE 2002) and the Canadian Maritimes (16% MAR 2002), and coastal erosion in Europe (EU 2011, 2014). Dredging was listed in the Canadian Maritimes (49% MAR 2002) and New Zealand (10% NZ 2011). Other identified threats included ships and marine traffic as well as invasive species, which were listed by respondents in six and five surveys, respectively. Aquaculture was identified as a threat in 4 North American surveys as well as in Europe (EU 2011), Ireland (IRE 2012) and Taiwan (TAI 2010). Marine renewable energies were only mentioned as a threat in EU 2011 and IRE 2012.

3.2. Marine protection

Across ten surveys, 73% (± 3%) of respondents were in favor of or support for marine protected areas in their region or country (Fig. 5). Support was lowest in Puerto Morelos Reef National Park in Mexico

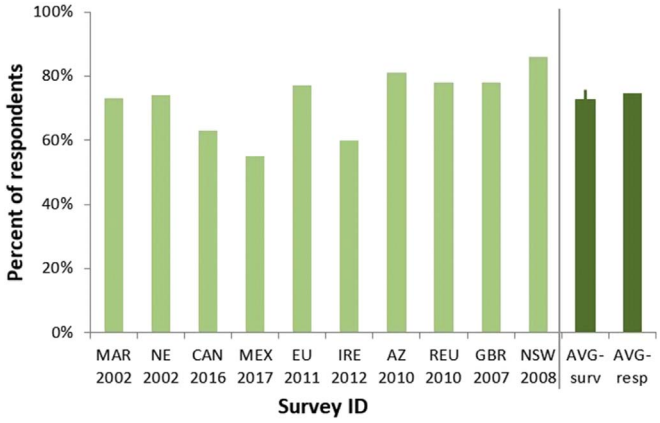

Fig. 5. Percent of respondents who are in support or favor of marine protected areas across individual surveys, and the average across surveys (AVG-surv, mean ± SE, n = 10) and weighted by the number of respondents in each survey (AVG-resp, mean ± SE, n = 13,967). See Table 2 for details on individual surveys.

(55% MEX 2015) and highest in Jervis Bay and Solitary Islands Marine Parks in New South Wales, Australia (86% NSW 2008). Support was also high in the Azores (81%, AZ 2010), the Great Barrier Reef Marine Park (78% GBR 2007) and Reunion Island (78% REU 2010). In Europe, support ranged from a low of 65% in Poland to a high of 86% in Portugal (average 77% EU 2011, Potts et al., 2011), while it was only 60% in Ireland (IRE 2012). One additional survey in Puget Sound, Washington (PS 2013), ranked support from a low of 1 to a high of 5, with an average score of 4.13 indicating broad support.

In most surveys, respondents where first asked whether they know what an MPA is, or were informed about the concept of an MPA. However, in Kenya < 40% of respondents could clearly identify what the purpose of an MPA is and 63% of residents in the Azores had not heard the term prior to the survey (Ressurreição et al., 2012).

When asked about the area of ocean that is currently protected in their region or country, the majority of respondents overestimated the amount protected as MPAs or marine reserves (Fig. 6, Fig. A1), which was < 1% in all surveys at the time they were performed (Edge Research, 2002; Parnell et al., 2005; Gardner et al., 2008; Eddy, 2014; Hawkins et al., 2016) except Kenya (~4%, Wells et al., 2007). In addition, an average 26% of respondents across surveys did not know

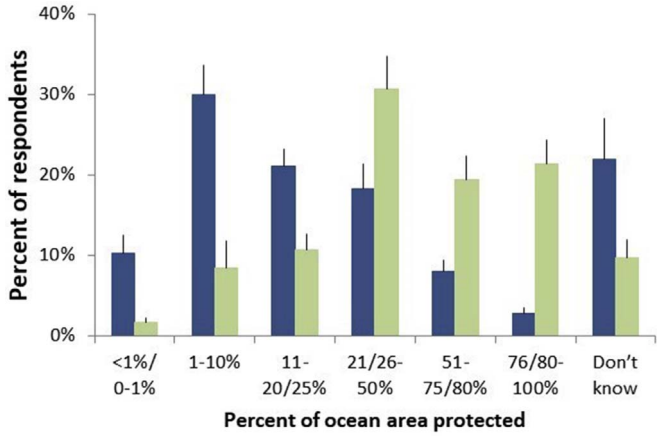

Fig. 6. Percent of the ocean area believed to currently be protected (dark) and desired to be protected (light) by respondents across 11 different surveys. The actual amount being protected was < 1% in all surveys except Kenya (~4%). Note that the provided % ocean area ranges varied between surveys. See Fig. A1 for graphs of individual surveys.

what the current amount of protection is (Fig. 6). In comparison, most respondents wanted to see more ocean area protected than currently is (Fig. 6), with > 30% of respondents wanting to see between 20 and 50% protected and about 40% of respondents wanting to see between 50 and 100% protected. We note, however, that not all respondents clearly recognized the purpose of an MPA or marine reserve and the restrictions they may entail for marine resource users.

Comparing different age groups in Nova Scotia, youths overestimated that the percentage of ocean area currently protected more than adults (Fig. A1a), and were also found to want a larger area of ocean being protected than adults. Comparisons of surveys conducted in different years were possible for both New Zealand (Fig. A1e) and the UK (Fig. A1f). In both countries, more respondents estimated the amount of ocean area currently being protected correctly in 2011 (10%) than in 2005 (4–5%). Additionally, most respondents wanted to see more ocean area protected in all survey years in the UK, as well as in Kenya and Nova Scotia (Fig. A1), while the difference between current and desired levels of protection was not as pronounced in New Zealand.

4. Discussion

The goal of this study was to quantitatively compare and synthesize public perceptions of ocean threats and protection from around the world. Although comparing information across different perception surveys proved challenging due to the lack of standardized survey methods and design, there was general consensus among respondents across surveys and countries on a number of issues, including: that the marine environment is under threat, that the major threats are pollution and fishing, that there is support for marine protected areas, and that more ocean area should be protected than currently is. Yet there were also some notable differences in perceptions between different survey regions, survey years and age groups reflecting individual concerns and varying levels of awareness or understanding across studies. Both the emerging general patterns and the differences in public perceptions can help inform marine managers, policy makers, conservation practitioners and educators to improve management and conservation towards a more sustainable relationship between people and the sea (Jefferson et al., 2015; Daigle et al., 2016; Gelcich et al., 2016; Lacroix et al., 2016; Potts et al., 2016). In addition, our work provides a baseline for future research on marine public perceptions and highlights the challenges of a young and growing research field that would benefit from more consistent survey design and standards to increase comparability.

4.1. Threats facing the ocean

From North America to the Azores and New Zealand, there was a clear perception that the marine environment is under threat from human activities. Although many citizens worldwide have limited understanding of marine science and ocean issues (Steel et al., 2005; Fletcher et al., 2009; Eddy, 2014; Guest et al., 2015), the consistent expression of concern about threats may help policy makers and regulators progress towards more sustainable management of the oceans (Mora et al., 2009; McKinley and Fletcher, 2010, 2012). Moreover, developing regulations around issues that people care about enhances the probability of compliance by increasing ownership, an important building block for responsible environmental behavior. Even if understanding of ocean science is low, people may still highly value and care about the ocean (Guest et al., 2015; Daigle et al., 2016). Perceptions of the level of threat varied between different age groups and surveys, likely reflecting different levels of awareness or understanding amongst respondents (Jefferson et al., 2015). For example, youths in Nova Scotia, Canada were the least likely to believe the marine environment is under threat, and less likely than adults from the same region. Yet when asked to rate the level of threat, youths were the most likely to answer they did not know, indicating limited awareness or understanding of human influences on the ocean. This is corroborated by poor ocean science knowledge test scores in Nova Scotian youths despite growing up near the sea (Guest et al., 2015), highlighting the need for increasing ocean awareness and ocean literacy (Fletcher and Potts, 2007; COSEE, 2013). There was also an interesting discrepancy between answers to the questions about the level of threat and the level of health of the ocean. This suggests that the way questions are asked influences the respondents' answers (Guest et al., 2015), highlighting the need for standardized questions to increase comparability across surveys.

Across all surveys, a general consensus emerged about the top threats to the marine environment. Pollution was consistently selected as one of the top three threats followed by fishing. Both of these are long-standing marine environmental issues that have been highlighted in the media and environmental campaigns. In comparison, other threats such as habitat alteration, climate change and biodiversity loss were ranked lower, perhaps due to their lower direct visibility, greater complexity or, as in the case of climate change, because they are newer threats to the ocean. Comparing these rankings based on public perceptions with scientific evaluations highlights some differences. Kappel (2005) identified overexploitation (including fishing) as the top and habitat loss as the second most important threat to marine, estuarine and diadromous species in the United States, followed by pollution, invasive species and others. Similar rankings with exploitation first, habitat loss second, followed by pollution and other threats were identified as the main causes for the depletion and extinction of estuarine, coastal and marine species over historical time scales (Lotze et al., 2006; Dulvy et al., 2009). The Millennium Ecosystem Assessment (MEA, 2005) also ranked overexploitation followed by habitat loss as the highest threats to biodiversity in marine ecosystems, while Halpern et al. (2008) found that climate change, including warming and acidification, ranked as the highest threats in the global ocean and coastal ecosystems followed by fishing effects.

Based on these and other results, there appears to be a clear gap between public and marine expert perceptions of the top threats to the marine environment (Howard and Parsons, 2006; Potts et al., 2011; Ressurreição et al., 2012; Hynes et al., 2014). One explanation for this gap may be different levels of awareness or sources of information. While experts are more likely informed by scientific studies and data, the public receives most information through the media and personal experiences. In Scotland, for example, the public saw oil spills as a greater threat than marine professionals, likely because oil spills are highly visible events and receive major press coverage (Howard and Parsons, 2006). In Kenya, beaches have high levels of plastic litter, so

marine pollution by plastics is a very visible problem to the public. Different perceptions between experts and the general public may also arise from the area of the ocean that each group is familiar with. While the general public is more familiar with the nearshore coastal ocean, experts and scientists may have a broader view of the ocean. Overall, this difference between public perceptions and expert opinions highlights the need for increasing ocean literacy among the general public (COSEE, 2013; Guest et al., 2015).

When given the option to talk about more specific pollution threats, various issues were raised by respondents that may reflect distinct local or regional threats, or greater awareness and concern about certain environmental issues due to differences in understanding, culture or representation in the media (Howard and Parsons, 2006; Ressurreição et al., 2012; Guest et al., 2015). For example, there was concern expressed about marine litter and debris in Ireland, Europe and Kenya, waste dumps along the coast in the Azores, sewage in New Zealand, and oil spills and mercury pollution in Taiwan. When asked about fishing issues, New Zealanders were most concerned about commercial and recreational fishing, while poaching and illegal activities were of high concern in the Azores and shark finning, bycatch and ghost fishing in Taiwan.

Threats to marine ecosystems are changing, and while overexploitation and habitat loss may have been the most severe threats in the past (Kappel, 2005; Lotze et al., 2006; Dulvy et al., 2009), today the global ocean is highly affected by climate change, in addition to fishing, habitat alteration, and pollution (Halpern et al., 2008). Moreover, these cumulative impacts are increasing in most parts of the global ocean (Halpern et al., 2015). Across thirteen surveys asking about ocean threats, six listed climate change among the top three threats, including global warming and ocean acidification. This may reflect growing concern about climate change around the world, which could foster progress towards changing individual behaviors and increase public support for climate change regulations, policies, and governance (Mora et al., 2009; McKinley and Fletcher, 2010, 2012; Guest et al., 2015). However, when compared to other pressing issues in individuals' lives, both oceans and climate change often ranked lower than personal and societal issues such as economic stability, health, and education (Spruill, 1997, Potts et al., 2011; Hynes et al., 2014).

4.2. Marine protection

One important tool for more sustainable management of the oceans is the implementation of marine protected areas (MPAs; Worm et al., 2009; Lotze et al., 2011; Edgar et al., 2014; Lubchenco and Grorud-Colvert, 2015; UNEP-WCMC and IUCN, 2016). Our results indicate that most respondents were in favor of MPAs and wanted to see more ocean area being protected. However, most respondents did not know or overestimated the amount of ocean area currently under protection, and in some cases did not understand the purpose of an MPA or marine reserve. This may in part be due to the still very low percentage of ocean area that is actually being protected (< 1% in most countries surveyed) compared to the much larger (15%) and likely more familiar protected area on land (CBD, 2014; Lubchenco and Grorud-Colvert, 2015). Yet the increase in marine protection over past decades, from less than 1% globally in 2000 to about 4.1% in 2016 (UNEP-WCMC and IUCN, 2016), may also mean that more people have heard of marine protected areas and their benefits. Still, 63% of residents in the Azores revealed they had not heard of the term prior to taking the survey (Ressurreição et al., 2012), and a similar percentage was found among Kenyan beach goers.

Interestingly, when asked how much of the ocean should be protected, most chose > 50% and some even 76–100%. Although many surveys briefed or asked participants about what an MPA is, there may be limited understanding of the potential trade-offs required for protecting > 50% of ocean area. In many MPAs, there are restrictions on resource uses and methods of extraction, which can create hardship or job losses for some people. On the other hand, once established, MPAs can provide benefits for resource users, tourism, managers, and the general public – creating a win-win situation (Worm et al., 2006, 2009; McCook et al., 2010; Edgar et al., 2014). For future research, it would be interesting to more deeply evaluate the respondents willingness to pay, for example which privileges they would be prepared to give up for an MPA as well as their expectations of potential benefits they would derive from an MPA. Several international experts and organizations have recommended that 20–50% of the ocean should be protected within the 21st century to adequately protect and conserve marine biodiversity (Lubchenco and Grorud-Colvert, 2015). While many nations aim to achieve 10% of marine area protected recommended by the AICHI target 11, others strive toward 30% recommended by the 2014 World Park Congress. The general and consistent public support of marine protection documented here could enhance participatory management and overall success of marine protection (Worm et al., 2009; McCook et al., 2010; Edgar et al., 2014).

It is important to note that MPAs are not capable of addressing all the threats facing the oceans today, as it is just one of many marine management and conservation tools (Worm et al., 2009; Lotze et al., 2011). However, MPAs can be effective in mitigating some issues of overfishing, offer protection for a variety of threatened or vulnerable species and habitats in selected areas, and provide spillover benefits to areas outside reserve boundaries (Worm et al., 2006; McCook et al., 2010; Edgar et al., 2014). In addition, more proactive or restrictive management measures are being implemented to enhance the sustainable management of the ocean and enhance rebuilding and restoration efforts (Worm et al., 2009; Lotze et al., 2011). A recent study showed that 13% of the ocean area is experiencing a decrease in human impacts, mostly in the Northeast and Central Pacific and Eastern Atlantic (Halpern et al., 2015). Whereas climate change impacts continue to increase in the global ocean, and land-based human activities continue to impact coastal waters, impacts from four of five types of fishing have decreased over the past decade (Halpern et al., 2015). Growing awareness and concern about marine pollution and climate change may foster similar changes with respect to these threats in the future. Thus, future research on marine perceptions could consider asking the public about their understanding of a broader range of available management tools and solutions to marine threats, and their support and willingness to pay for the different approaches.

4.3. Challenges and opportunities

One of the greatest challenges in comparing and synthesizing various survey results was to identify consistently phrased questions and answer options that could be compared across studies. Although some answers could be directly compared or grouped for comparison, several interesting survey aspects and details (e.g. specific threats) could not be compared across more than a few surveys. In addition, the way questions were asked, such whether asking about the level of threat or the level of health, seemed to influence the respondents' answers. We therefore recommend that future surveys draw from existing studies and this summary to use consistent phrasing of questions and answer options for enhanced comparability. When using public surveys, marine perception researchers could agree on standardized survey questions and design to be used around the world. This has already been done in Europe, where standardized surveys performed online were spread across seven (EU 2011) and later ten countries (EU 2014) reaching large sample sizes of 7000 and 10,000 respondents, respectively (Potts et al., 2011; Gelcich et al., 2014).

Additionally, it would be useful to repeat the same surveys every few years to gain insight into changing perceptions within a population (Whatmough et al., 2011; Saenz-Arroyo et al., 2005). This was done in New Zealand (NZ 2005, 2011) and the UK (UK 2005, 2010, 2015) and showed, for example, that in more recent surveys a greater percentage of respondents estimated the current ocean area protected correctly and

fewer respondents didn't know. These results may indicate an increasing level of understanding and awareness. In addition, New Zealanders in 2011 had a slightly more optimistic perception of the level of threat to the ocean, and believed that more of the ocean area is protected compared to 2005. This may reflect either greater awareness or better management in New Zealand (Eddy, 2014). Hence, surveys conducted repeatedly over time could track changes in public awareness and perceptions, for example about MPAs or other management measures, and evaluate whether changes in public opinion reflect changes in environmental status.

Perceptions are rarely distributed homogenously within society (Guest et al., 2015; Jefferson et al., 2015) and there is also a need to diversify age and other target groups, identify special interest groups and ensure representation of traditionally marginalized voices in survey research. Covering more countries around the world, such as in South America, Africa and Asia, would help identify more region- and cultural-specific issues (Ressurreição et al., 2012; Jefferson et al., 2015). Moreover, a consistent comparison between experts and the general public would aid in identifying local and regional issues and perceptions as well as different levels of understanding or awareness (Ressurreição et al., 2012; Guest et al., 2015). Lastly, when it comes to asking the public about certain choices, such how much of the ocean they would like to see protected, it would be helpful to incorporate questions gauging their deeper understanding of the consequences of their choices, such as their willingness to pay or their expected benefits (Thomassin et al., 2010).

5. Conclusion

Our comparison and synthesis revealed that citizens from around the world have a clear understanding that the ocean is threatened by human activities, and that pollution and fishing as well as habitat alteration, climate change and biodiversity loss are major threats. Some differences in the ranking of top threats between public perceptions and scientific evaluations might be explained by limited understanding or skewed awareness associated with different information sources (e.g. media versus scientific publications) or specific areas of the ocean considered (e.g. coastal versus offshore). Generally, most respondents support marine protected areas and want to see a higher amount of ocean area protected. This does not necessarily mean that people are willing to give up goods and benefits gained from ocean uses, or are willing to pay more for protection and management. However, increased awareness and concern about ocean threats and protection could translate into changing of individual behaviors as well as regional, national and international stewardship and governance. Enhanced marine education and ocean literacy programs could help increase people's understanding of the ocean, including the benefits and services provided for humans and their influence on the marine environment (COSEE, 2013; Daigle et al., 2016). Ocean-literate members of society can use their knowledge and understanding to raise awareness and make responsible decisions. They can translate their knowledge into action, thereby acting as responsible marine citizens and reducing negative human impacts on the ocean (McKinley and Fletcher, 2010, 2012). This bottom-up approach can act in concert with top-down regulations to enhance the protection and sustainable management of the ocean. Public awareness is a first key step towards this goal and highlights the value of public perceptions research in marine conservation and management.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ocecoaman.2017.11.004.

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